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Electric Vans — Progress Report

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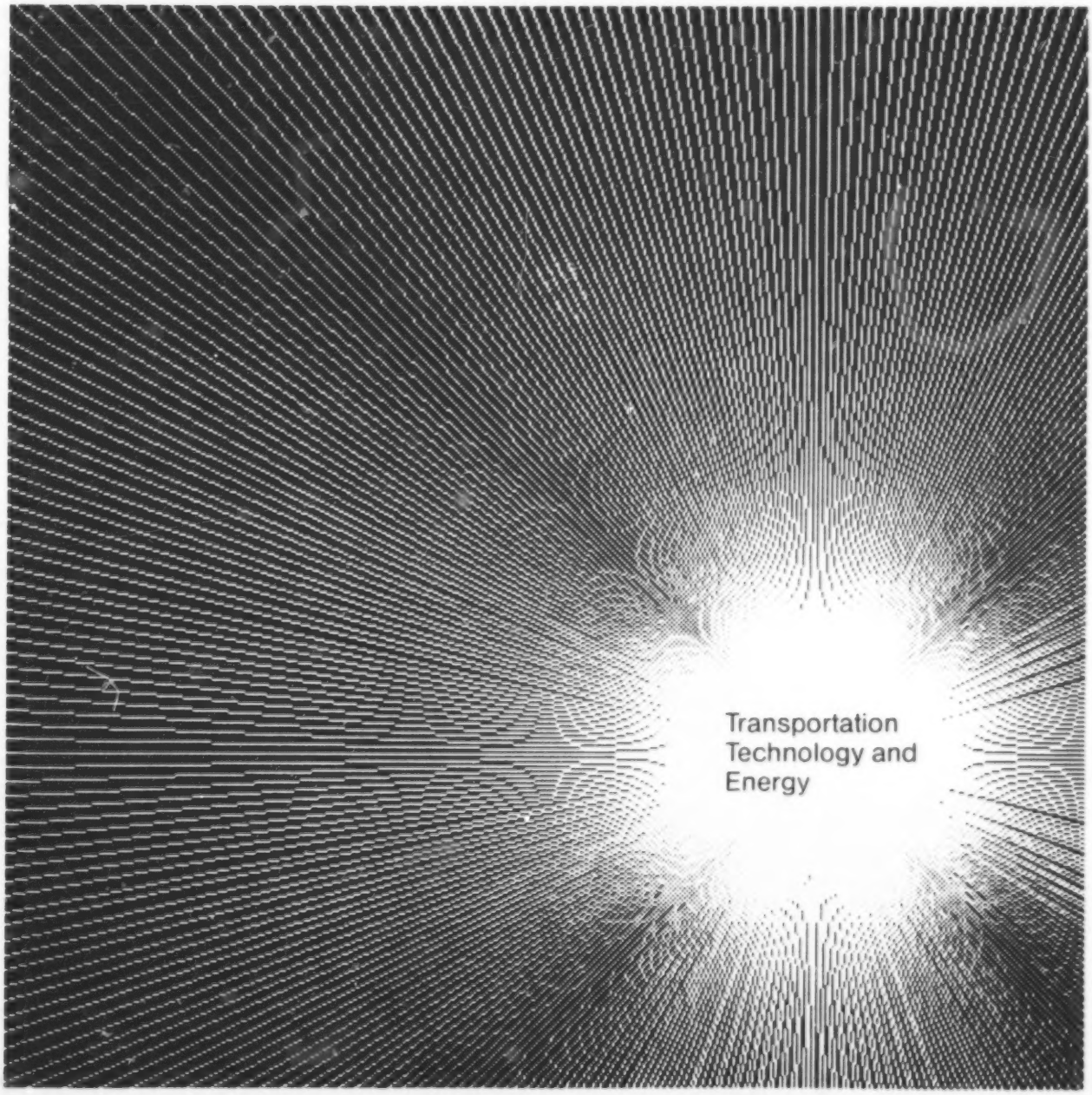

EV-86-01

Electric Vans — Progress Report

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Abstract:

The Ontario Ministry of Transportation and Communications is conducting an over-the-road evaluation of two General Motors Griffon electric vans for the Ontario Centre for Automotive Parts Technology. The objective of the program is to establish an understanding of the behaviour, reliability, cost, and operational limitations of electric vehicles in routine urban traffic in Canada.

This report describes vehicle preparation and testing before the vehicles were put into regular courier service.

Key Words: Griffon van, Bedford van, electric vehicle, lead-acid battery, testing

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EXECUTIVE SUMMARY

This report documents the preparation and testing of the two Griffon (Bedford) electric vans before they were used in courier service runs. The purpose of these tests was to ensure that the electric vans would be capable of carrying out their daily courier service between the Queen's Park complex and the Ministry of Transportation and Communications, Downsview.

The results of this program are summarized as follows:

- The electric van is capable of seating up to eight passengers with some cargo. The maximum payload is about 645 kg (1420 lb).

- The vehicle range per charge is about 80 km. Given two opportunities to charge the battery, each no less than 30 min, the electric van will be capable of completing its 100 km daily courier service.

- The maximum speed of the electric van is about 85 km/h. The vehicle is capable of coping with urban traffic conditions in Metropolitan Toronto.

- The two electric vans were put into service on May 14, 1986.

1/ INTRODUCTION

In 1985, after discussions with Ministry of Energy (MENY), Ministry of Industry, Trade and Technology (MITT), and the Ontario Centre for Automotive Parts Technology (OCAPT), the Ministry of Transportation and Communications (MTC) agreed to test two Griffon (Bedford) one-tonne electric vehicles under specific conditions. The project objective was to establish an understanding of the behaviour, reliability, cost, and operational limitations of electric vehicles in routine urban traffic conditions in Canada. The funding of the project is provided by MENY, and OCAPT is responsible for the overall project management.

The Engineering Equipment Office, which is responsible for the operation and management of all ministry mobile equipment, and the Automotive Technology and Systems Office agreed to put the two electric vans into courier service. The operation was to be the daily scheduled service between Queen's Park and the MTC Downsview complex, a round trip of 33 km.

This report deals mainly with activities of vehicle preparation and testing that were required to determine if the vans could perform the courier service operation in a satisfactory manner. A report of the daily courier service will be given after a six-month period of operational experience is accumulated.

A summary of the vehicle data and testing results are presented in the Appendices.

2/ OBJECTIVE

The test program was carried out to establish an understanding of the behaviour, reliability, cost and operational limitation of the two Griffon (Bedford) electric vans under daily scheduled courier service in Canadian conditions. The test results can be compared with those of conventionally powered vehicles to assess the benefits of using electric vehicles in Ontario. The information gained from this program is available to other North American operators, vehicle suppliers, Bedford Commercial Vehicles (BCM), and Lucas Chloride Electric Vehicle Systems Ltd. (LCEVS) to provide user feedback which will lead to further improvements in this new technology.

3/ VEHICLE DESCRIPTION

The Griffon van was manufactured by the Bedford Commercial Vehicle Company (BCVC) in Luton, England, and is the first electric vehicle to be assembled on a regular assembly line. BCVC simply fit the electric drive package supplied by LCEVS instead of the normal engine and transmission.

This section deals mainly with the electric drive package. Appendix A provides more detailed information on the vehicle.

3.1/ Traction Battery

The power and energy source of the propulsion system is a lead-acid battery pack which consists of thirty-six 6-V modules connected in series. The battery pack is located beneath the floor and is attached to the vehicle frame by three lock-pins. The weight of the battery pack complete with the battery heating system is about 1275 kg.

3.2/ Traction Motor

The traction power of the vehicle is provided by a Lucas 40 kW, separately-excited dc motor. A fixed-gear ratio primary drive unit is used to couple the motor to the rear-wheel differential. The maximum motor speed is 6000 rpm and the maximum motor torque is 250 Nm.

3.3/ Traction Motor Control

The motor power and speed is controlled by means of two controllers. The main power controller is a thyristor chopper which controls the voltage and current supplied to the armature circuit. A second low power controller is included to control the motor field circuit. The combinations of the two controllers provide drive control and regenerative braking. Figure 1 shows a simplified controller block diagram taken from the training material provided by LCEVS.

3.4/ Auxiliary Power

The auxiliary 12 V battery to supply lights and accessories is charged from the battery pack through the Lucas PDC 1A/216 dc-dc convertor. The unit is a solid-state device that maintains a stable output voltage over a wide input voltage range.

3.5/ Traction Battery Charge

The charging of the battery pack is through an off-board Chloride Spegel S1P 108/30 charger. Voltage input is from 200 to 250 V single-phase ac. Nominal input current is 45 A. Nominal output voltage is 216 Vdc. Output current rating is 30 Adc. The charger was designed for use with lead-acid motive power batteries.

3.6/ Vehicle Heating

Vehicle compartment heating and windshield defrosting is provided by a separate Eberspacher D 4L heater. This may be operated on diesel engine fuel or light fuel oil. If winterized diesel fuel for low temperatures is not available, then kerosene may be added to the diesel fuel.

3.7/ Seating

EV 11: 12-Seat Passenger Van

- The nine seats behind the driver's seat were not equipped with seat belts.
- The spare tire was not fixed on a specific spot.

EV 12: Cargo Van

- The interior behind the driver's seat was not panelled.
- The spare tire was mounted on top of the left rear wheel well.

Both vehicles were later converted to nine-seater passenger carrying vans by a local contractor, as described in this report.

4/ PREPARATIONS

A number of preparations were carried out so that the departments responsible for courier service operations were in a position to put the electric vans into courier service. These major preparations are listed in this section.

4.1/ Vehicle Check - Preliminary

When the two vehicles were picked up at the GMC Truck Centre, Toronto, a visual inspection for physical damage was made. A letter with complete findings from the preliminary check was sent to LCEVS with copies to all concerned. The list of findings is summarized in Appendix B.

4.2/ Vehicle Operator Training

An agreement was reached between LCEVS and MTC that the training course for vehicle operators be given at the MTC premises, Downsview. Eight MTC personnel successfully completed the course and one member from the Engineering Equipment Office participated as an observer.

Mr. Peter Jennison, Service Development Engineer, from LCEVS was the instructor. The course was concise, informative, and practical, covering starting the heater, trouble shooting the controller and removing the battery pack. Training material, including a maintenance manual, an operator's training course binder, a set of service bulletins, some subsystem pamphlets, and a drawing of the wiring diagram, was supplied to each of the participants.

4.3/ Vehicle Commissioning

David Harris of LCEVS commissioned the two vehicles at the MTC premises. The acceptance check was completed to our satisfaction. The checklists for both vehicles are attached in Appendix C.

A modification was required which involved drilling a 16 mm hole in the motor mounting bracket. This change permitted the elimination of direct metal-to-metal contact between the motor and the chassis and noticeably reduced the acoustic noise level in the vehicle interior. Figure 2 shows the faulty metal contact point on the mounting bracket.

4.4/ Completion of Battery Pack Heater System

The two vans were delivered to MTC with heater panels included in the battery pack. The wiring, however, was not completed to allow the

heaters to operate. The complete hook-up of the heater panels and insulators was done later by personnel from LCEVS, UK, at the MTC premises.

The heating system consists of two trace heaters, six heating panels, insulation around all water piping, insulating pads around the battery pack, and four thermostat switches. The trace heater is used around the watering block and water pipes from the watering block leading to the battery pack. The six heating panels are laid underneath the 36 battery modules. The power flow for the system is controlled by a separate on-off switch mounted on the front panel of the charger. For a 240 V single-phase line voltage, the rating of the heater system is 1.55 kW. Figure 3 shows a schematic diagram of the system. Figure 4 shows the heater cable terminated at the junction box.

4.5/ Improving the Autofil Topping Up System

One autofil trolley was delivered to MTC with the two vehicles. The autofil trolley is used to top up the electrolyte level in the traction battery. The autofil topping up system will not function if there is a leak in the water pipe circuit of the battery pack. Figure 5 shows a schematic representation of the autofil in operation. The original plastic lids had a tendency to come loose and cause leaks in the water pipe system. A complete set (108 pieces) of improved lids with double thickness lid retention lugs was installed in both vehicles early in April by the service personnel from LCEVS, UK. Figure 6 shows one battery cell with its lid removed.

4.6/ Vehicle Interior Modification

The original seats installed in the EV 11 did not meet DOT specifications and were not equipped with seat belts. The OCAPT contracted a local supplier to complete the insulation, panelling, carpeting, and the installation of seats complete with seat belts for each van. The seats, seat mountings, and seat belts are guaranteed by the supplier to meet or exceed CMVSS specifications.

To meet the requirements of the courier service operation, both vehicles were equipped with nine seats. There is approximately 0.85 m^3 of cargo space behind the rear seats. Figure 7 shows the interior layout of the vehicle.

Insulation was fitted to the van to reduce the level of noise in the van as it was being used to carry passengers. This also provided an opportunity to improve the internal appearance.

Because of space limitations, the spare tire is not carried onboard the vehicle; one tire is stored at the Bay Street government garage, and a second tire is kept at the south garage, District 42 at Downsview.

4.7/ Door Entrance Improvement

The entrance to the front seats of each vehicle has a two-step access and is considered adequate for passengers to step up and enter. A running board was added to the side entrance, making it a two step access instead of the 0.53 m single step that it was originally, which was too high for most passengers. Figure 8 shows the rubber padded running board installed by the Engineering Equipment section of MTC.

4.8/ Roof Ventilation

The window opening space behind the front doors is approximately 0.21 m^2 and is near the middle section of the vehicle length. It was estimated that the air ventilation particularly near the rear seats would not be sufficient, and the interior temperature during summer operation would be uncomfortable. A two-position roof vent with screen was installed above the rear centre seat. Figure 9 shows the roof vent.

4.9/ Added Audio System

The propane vans, replaced by the electric vans, were equipped with AM radios. It was felt that the replacement should provide similar facilities within a reasonable budget. An AM/FM radio with cassette player, complete with two three-way speakers, was installed in each vehicle. The interference generated by the electrical drive system make it impossible to hear the AM radio, but the FM radio and the cassette player work well.

4.10/ Battery Pack Charger Installation

As required by the courier service operation, battery chargers were installed in the Bay Street government garage and in the south garage, District 42, Downsview. Each charging station is equipped with an ac kWh meter and a load research recorder.

The ac kWh meter allows the operator to manually record daily energy consumption, and the load research recorder provides daily load distribution recordings. The meter and the recorder were provided to us at no cost by Ontario Hydro. Figure 10 shows one of the charger stations.

5/ TESTING PRIOR TO COURIER SERVICE OPERATION

A number of tests were made before the vehicles were put into courier service. The purpose of the tests was to ensure that the battery would have the capacity to provide an uninterrupted courier service.

5.1/ Battery Pack Thermal Characteristics

It is known that one of the factors that affects battery capacity is electrolyte temperature. At low temperatures, slow chemical action at the plates decreases its capacity. When the battery heating system was complete, a number of tests were conducted to determine the thermal characteristics of the battery pack. Three thermocouples were glued to the top of three battery modules on both battery packs. Figure 11 shows the locations of the thermocouples. A fourth thermocouple for sensing the ambient temperature was placed about 15 cm behind the rear door of the vehicle in the open space.

To determine the battery pack cooling characteristics, the vehicle was first stored in the garage at room temperature with the battery pack fully charged for at least 16 h. Then the vehicle was driven outside where it was subject to ambient temperature. With the battery charger and battery heater not connected, the four thermocouple outputs were recorded. Figure 12 shows the temperature drop of the four thermocouples. The slopes of the temperatures of thermocouples 1, 2, and 3 are approximately 2°C/h.

The battery pack heating was resumed at the end of the cooling test. The vehicle was parked outside with the battery charger off. Figure 13 shows the temperature changes of the four thermocouples after the battery heater was connected and turned on. Of the four thermocouples, number 3 has the steepest slope at approximately 2°C/h.

When interpreting the outputs of thermocouples 1, 2, and 3, it should be understood that the temperatures indicated were not the temperatures of the electrolyte. Because the thermocouples were located on the top of their respective modules, the indicated temperature was expected to be lower than that of the electrolyte.

5.2/ Battery Pack Heater Power Rating

The total power rating of the two trace heaters and the six heating panels is 1.55 kW according to the schematic diagram; a measurement was

made to confirm the heater rating. The vehicle was parked outside for 24 h with the battery in fully charged condition and the charger turned off. The ambient temperature was -9°C when the heater was turned on and climbed to -7°C at the end of the 5 h and 40 min test period. The heater was on 100% of the time. The ac energy consumption of this period was recorded. Table 1 gives the summary of the test.

5.3/ Battery Pack Heater Energy Consumption

There are four thermostat switches connected in the heater system. The switches open at 25°C and close at 22°C; therefore, the average rate of energy consumption of the heater is normally below its power rating. A test was made to determine the average rate of energy consumption of the heater on a typical winter day.

The vehicle was parked outside, with the battery fully charged and the charger left on, during the test period. The heater was then turned on and the energy consumption for the test period was recorded. The average rate of heater energy consumption was calculated by deducting the charger energy consumption from the total and then dividing by the time interval. Table 2 outlines the test results.

5.4/ Battery Charger Energy Consumption

The LC Spegel S1P 108/30 automatic taper charger continuously monitors the battery. When the battery pack is fully charged, the charger will turn on for about 10 min every 6 h to freshen the battery. The energy consumption rate was obtained by leaving the charger on for a twenty-four hour period with the heater turned off. The charger was left on and the vehicle was stored inside at normal room temperature. Table 3 summarizes the test.

5.5/ Battery Pack Charge and Discharge Efficiency

The term battery pack charge and discharge efficiency, or overall system efficiency, is defined here as the total dc output energy from the battery pack divided by the total amount of ac input energy into the battery charger and is expressed in percentage. The data were collected from the simulated courier service runs. The vehicle was loaded to its test weight, 3040 kg (6700 lb), and was operated along the courier service route. The battery pack was given different opportunity charges; the results are recorded in Table 4.

5.6/ DC Power Requirement at 80 km/h Constant Speed

The dc power requirement at 80 km/h constant speed on level road is required for setting up the test on the dynamometer. Several runs were conducted on level sections of Hwy 401, Hwy 400, and rural area of Jane Street north of Hwy 7. As the road conditions were not ideal, results vary from 24 kW to 29 kW. The average value 26.8 kW was used in setting up the dynamometer Table 5 lists five test results.

5.7/ Interior Acoustic Noise Measurement

The interior acoustic noise was measured by locating the microphone at the plane of and at the same height with the driver's ears, about 30 cm from his right ear.

Measurements were made before and after the vehicles had their interior settings modified. All measurements were made while the vehicles were driven on the same level sections of a rural road, see Table 6.

5.8/ Simulated Courier Service Runs

To have the vans complete a required 100 km daily courier service run with its 80 km range battery pack, opportunity charges were necessary. The simulated courier service runs were made to find out how to schedule the opportunity charges into the fixed courier service schedule.

The EV 12 was instrumented to collect data on battery Ah output, battery kWh output, outputs of the three thermocouples which were permanently glued to the top of three battery modules, output of one thermocouple which monitored the ambient temperature at the back of the vehicle, and input ac energy to the battery charger were all recorded.

The EV 12 was loaded to its test weight, 3040 kg (6700 lb), and was driven along the courier service route. The conclusion from the simulated runs was that two opportunity charges, no less than 30 min each, would be necessary for the battery pack to have enough energy to complete the 100 km daily service run. Each electric vehicle has two opportunity charge periods that range from 30 to 45 min, within their fixed courier service schedules. Table 7 is a summary of the input and output energy of the simulated courier service runs. Figure 14 gives the courier service route map. Figure 15 is a plot of the temperature changes of the four thermocouples during three consecutive return courier runs.

There are four overnight charges and one over-weekend charge per week for the courier service operation. By using the test results of February 10, 1986 in Table 4, the estimated average weekly system efficiency (battery output versus charger input) will be 70.38%. The estimated ac energy consumption will be 0.50 kWh/km.

In Table 7, the battery pack outputs of the last northbound trips on January 31, 1987 and on February 13, 1986 are not available. The on-board 120 Vac power supply which powered the recording instruments had to be turned off. The 12 V auxiliary battery voltage was dragged down by the inverter load such that it affected the operation of the vehicle control system. The battery pack outputs of the test conducted on February 18, 1986 were recorded for each round trip.

6/ FAILURES AND REPAIRS

The failures reported here are limited and are related to electric vehicle drive systems. Problems, such as a broken door handle, unrelated to the electric drive will not be included.

6.1/ Battery Pack Charger

One of the two battery chargers, Serial No. 3500943, was out-of-order on January 7, 1986. One contactor chattered continuously, and the charging current indicator continuously swung back and forth. There were signs of burning and overheating on the circuit board and on one of the contactors.

The charger was repaired by LCEVS on January 18, 1986. The repairs incurred no cost to MTC as it was still under warranty. The service was recorded on the Service Report No. F03974.

6.2/ Autofil Topping Up System

A problem was found in the autofil topping up system on January 24, 1986. It was discovered that the system was not functioning as the right-hand side of the EV 11 battery pack was being topped up. The water pump of the autofil trolley was continuously running but no water was being pumped out of the trolley into the battery pack.

The problem was twofold: the pressure valve of the autofil trolley was sticking causing loss of water pressure, and two of the Vaqualok lids of the EV 11 battery pack were popped open which caused the leak of the autofil topping up system. The two problems were fixed by LCEVS on February 26, 86.

The Vaqualok lids of EV 12 were also carefully examined. Caps with fractured lid retention lugs were replaced. Figures 16 and 17 show the Vaqualok lid replacement records for EV 11 and EV 12 respectively.

When the battery pack was put back into the vehicle, a spacer was inserted into the gap between the pack frame and the lock-pin hanger. The addition of this spacer stabilized the battery pack mounting position to prevent its lateral movement.

7/ CONCLUSIONS

Test results of the battery pack thermal characteristics show that both the cooling and heating rates of the battery pack in sub-zero temperatures are slow. Though the temperature outputs of the three thermocouples are not the temperatures of the electrolytes of their respective battery modules, it is safe to assume that the rates of fall for the electrolyte are below 3°C/h. During winter operation, if overnight charges are carried out in heated indoor areas, it is possible that the battery pack heaters might not be needed.

From the simulated courier service runs, it was found that the battery pack charge and discharge efficiency (or dc energy out divided by the ac energy in) ranged from 56% to 77%. The wide variations are due to two factors. Long hours on charge mode use energy on trickle charges and contribute to low overall system efficiency. Efficiency is also affected by the depth of discharge of a battery when it is placed on charge. A battery that is less than 80% discharged forces the charger to become a waster of energy. The estimated overall system efficiency for the courier service will be above 70%.

The measured dc power requirement at 80 km/h constant speed varied from 24 kW to 29 kW. The average value was 26.8 kW which is 0.6 kW higher than the figure given by Tennessee Valley Authority (TVA). The test results for dc energy and power consumption at constant speeds from TVA are listed in Appendix D.

The range of the electric van per battery pack charge is about 80 km. It is at least 20 km short of the required range for the daily courier service runs between the Queen's Park complex and MTC, Downsview. Two opportunity charges, each at no less than 30 min intervals, are scheduled between runs to enable the electric van to complete its daily runs. The estimated energy consumption (ac) for the courier service will be approximately 0.5 kWh/km.

The distances of vehicles behind the vans, as shown in the convex-shaped side mirrors, appear to be farther back than their actual distance. Drivers of the van should not rely on the side mirror image to accurately judge the distance of approaching vehicles.

The electric vans are ready to be put into courier service runs.

Table 1/ Battery Heater Power Rating

Test Date:	February 11, 1986
Battery Pack:	Fully charged
Vehicle Park:	Outdoor Parking
Battery Charger:	Off
Measuring Period:	From: 10:22 a.m. To: 4.02 p.m. Duration: 5.7 h
Average Ambient Temperature: (During Measuring Period)	-8°C
Energy Consumption:	8.8 kWh
Average Heater Power:	1.55 kW

Table 2/ Typical Battery Heater Energy Consumption

Test Date:	February 7, 1986
Battery Pack:	Fully charged
Vehicle Park:	Outdoor parking
Battery Charger:	On
Measuring Period:	From: 4:00 p.m. February 6, 1986 To: 8.40 a.m. February 7, 1986 Duration: 14.7 h
Average Ambient Temperature: (During Measuring Period)	-4°C
Total Energy Consumption:	18.388 kWh
Energy Consumption of Charger:	1.807 kWh
Energy Consumption of Heater:	16.581 kWh
Average Rate of Heater Energy Consumption:	1.128 kW

Table 3/ Battery Charger Energy Consumption

Test Date: February 6, 1986

Battery Pack: Fully charged

Vehicle Park: Heated indoor parking

Measuring Period: From: 9:45 a.m., February 5, 1986
To: 9:45 a.m., February 6, 1986
Duration: 24 h

Energy Consumption: 2.95 kWh

Average battery charger power required to trickle charge a fully charged battery pack for about 10 min every six hours is 123 Wh.

Table 4/ Battery Charge and Discharge Efficiency (Simulated Courier Service Runs)

Date	dc Energy Output kWh	ac Energy Input kWh	% Efficiency	Distance km
86-02-14	32.46	52.09 (over wk-end)	62.3	93.35
		44.84 (exclude wk-end trickle charge)	72.4	93.35
86-02-18	36.74	47.47	77.4	96.57
86-02-21	24.58	43.49 (over wk-end)	56.5	65.99
		36.24 (exclude wk-end trickle charge)	67.8	65.99
86-02-24	36.9	52.51	70.3	105.42

Table 5/ DC Power Requirement at 80 km/h Constant Speed

Test Vehicle: EV 12

Vehicle Weight: 3040 kg (6700 lb)

Run No.	Speed	Battery Output Power
1	80.5 km/h	28.5 kW
2	80.5 km/h	25.2 kW
3	80.5 km/h	29.0 kW
4	80.5 km/h	24.0 kW
5	80.5 km/h	27.4 kW
	Average	26.8 kW

Table 6/ Interior Acoustic Noise Measurement

Reference Pressure: 2×10^{-5} Pa

Vehicle Speed	EV 11		EV 12	
	Before Modified Interior	After Modified Interior	Before Modified Interior	After Modified Interior
48 km/h	67.8 db	N/A	75.2 db	70.6 db
80 km/h	74.0 db	N/A	79.7 db	72.8 db

Table 7/ Simulated Courier Service Runs

Date:	Battery Pack Outputs							
	Southbound		Northbound		Round Trip		Distance	AC Input
	AH	kWh	AH	kWh	AH	kWh	km	kWh
86-01-31	24.6	4.88	32.7	6.39	57.3	11.27	30.58	
	27.0	5.19	32.9	6.25	59.9	11.44	32.19	
	27.5	5.29	N/A	N/A				N/A
86-02-13	24.8	4.96	33.9	6.44	58.7	11.40	32.19	
	29.7	5.64	34.9	6.28	64.6	11.92	32.19	
	29.9	5.24	N/A	N/A				N/A
86-02-14	24.5	4.68	29.7	5.84	54.22	10.52	30.58	
								3.86
	26.7	4.88	35.1	6.16	61.8	11.04	32.19	
								4.90
	27.5	5.24	30.6	5.66	58.1	10.90	30.58	
								43.33 (over wk-end)
86-02-18	N/A	N/A	N/A	N/A	65.8	12.48	32.19	
								1.04
	N/A	N/A	N/A	N/A	64.4	12.02	32.19	
								7.90
	N/A	N/A	N/A	N/A	66.9	12.24	32.19	
								38.53
86-02-21	31.1	6.00	32.0	6.00	63.1	12.00	33.80	
								3.70
	34.4	6.04	36.0	6.54	70.4	12.58	32.19	
								39.79 (over wk-end)
86-02-24	24.4	4.76	33.2	6.22	57.6	10.98	30.58	
								4.95
	29.6	5.30	30.1	5.70	59.7	11.00	33.80	
								2.90
	28.7	5.18	32.8	5.86	61.5	11.04	32.19	
	25.0	3.88 (around parking lot)					8.85	
								44.66

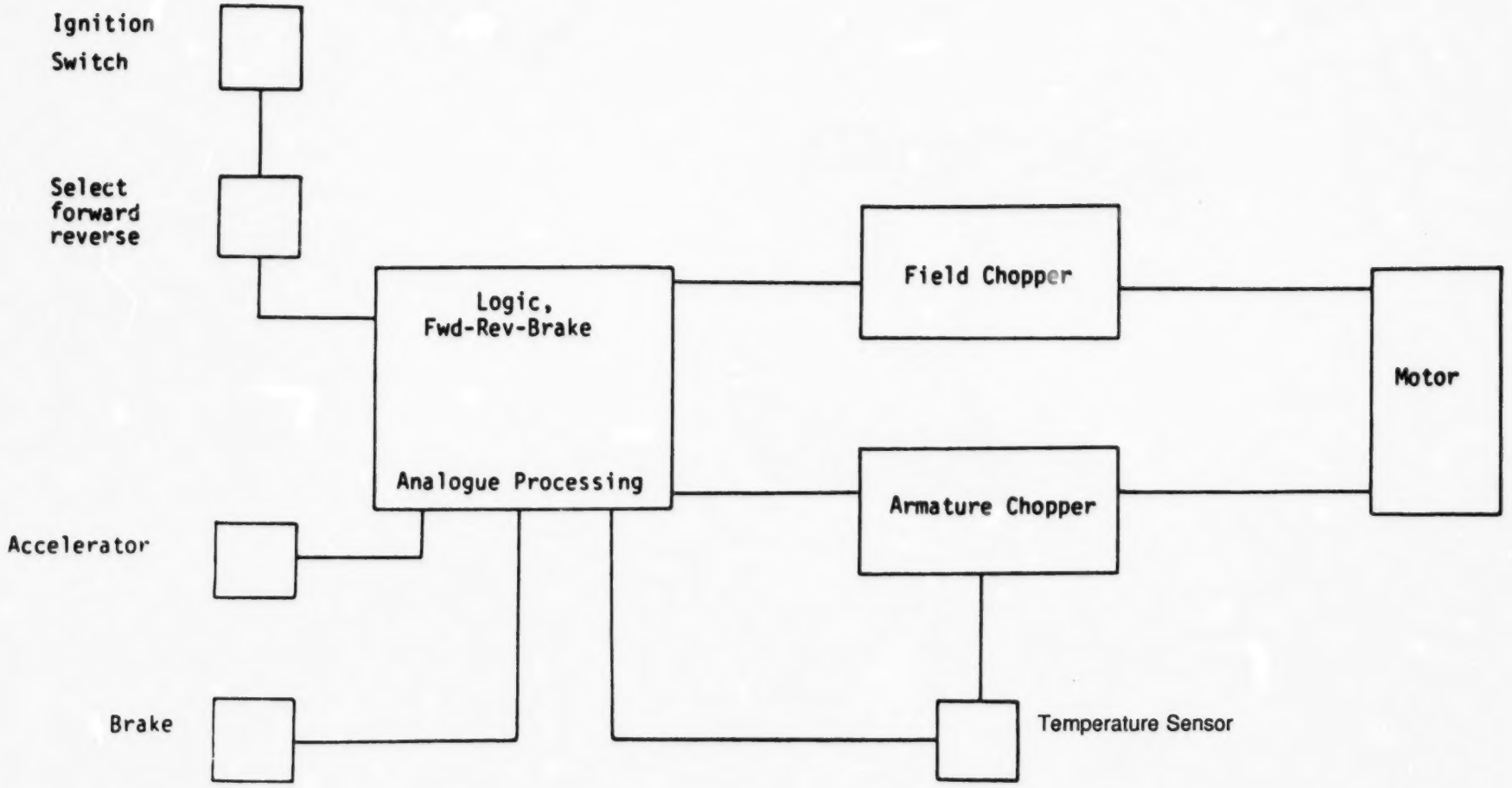


Figure 1/ Simplified Controller Block Diagram

Figure 2/ Motor Mounting Bracket

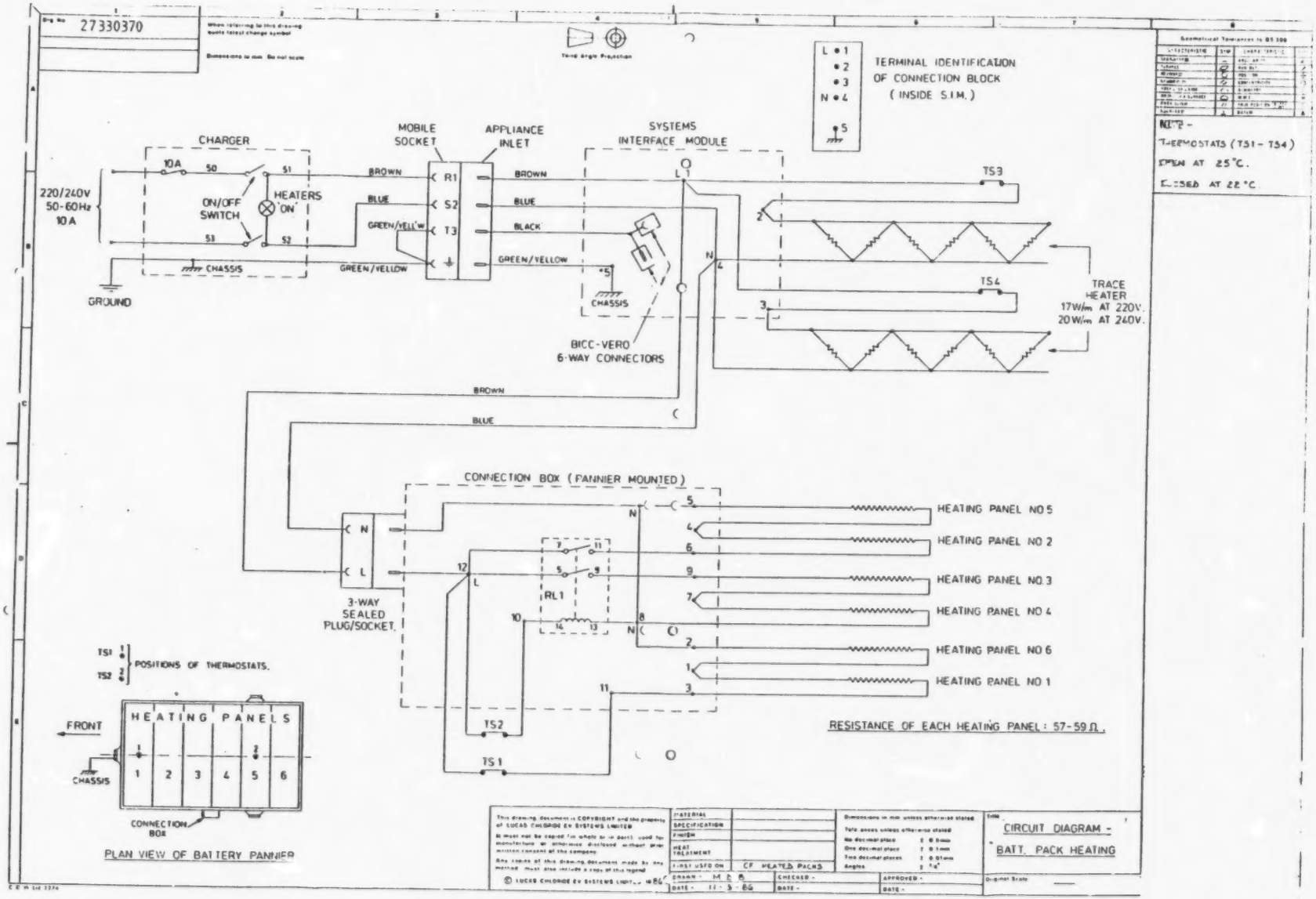


Figure 3/ Schematic Diagram of Battery Pack Heater System

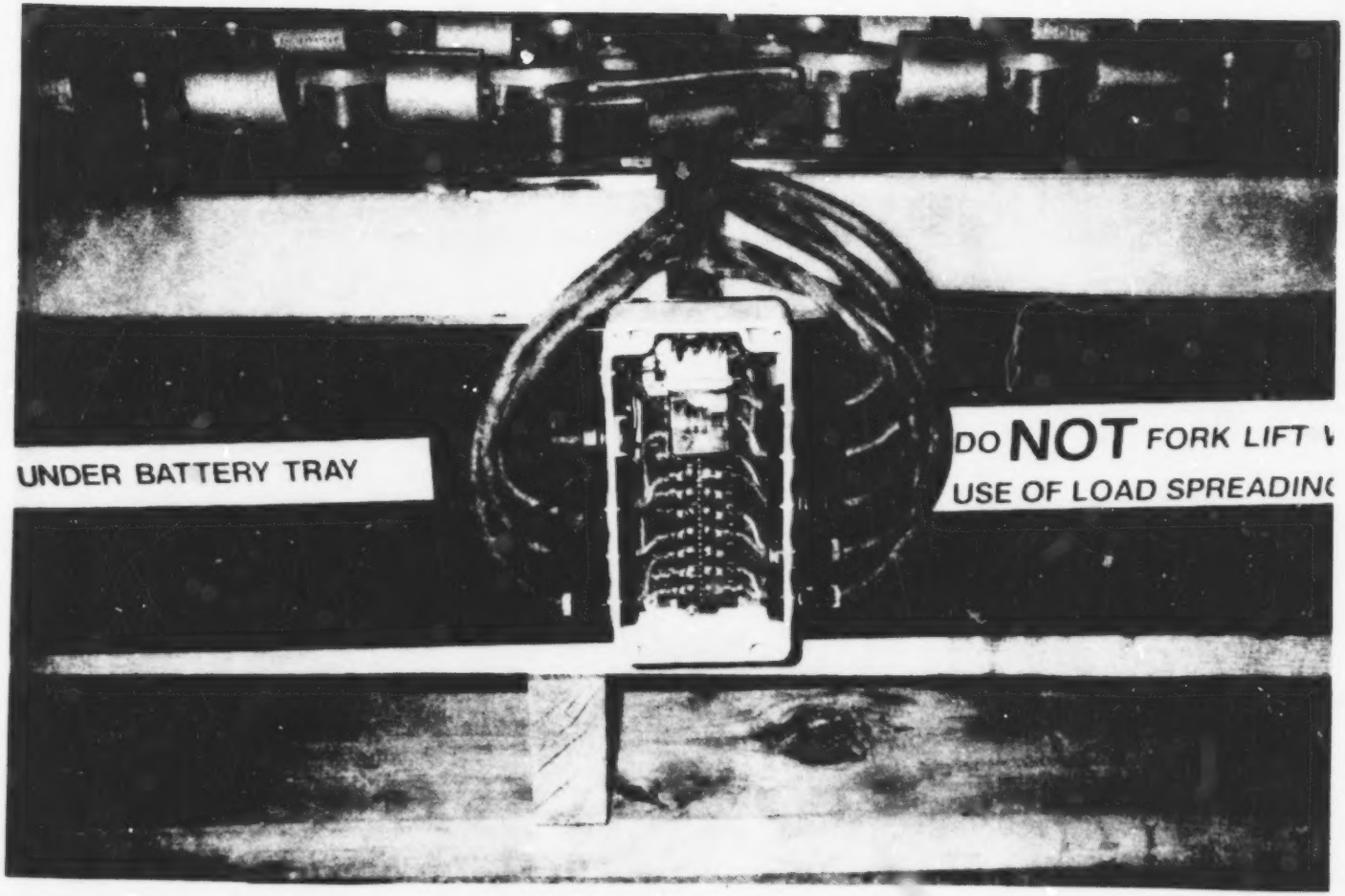


Figure 4/ Battery Pack Heater Cable Termination

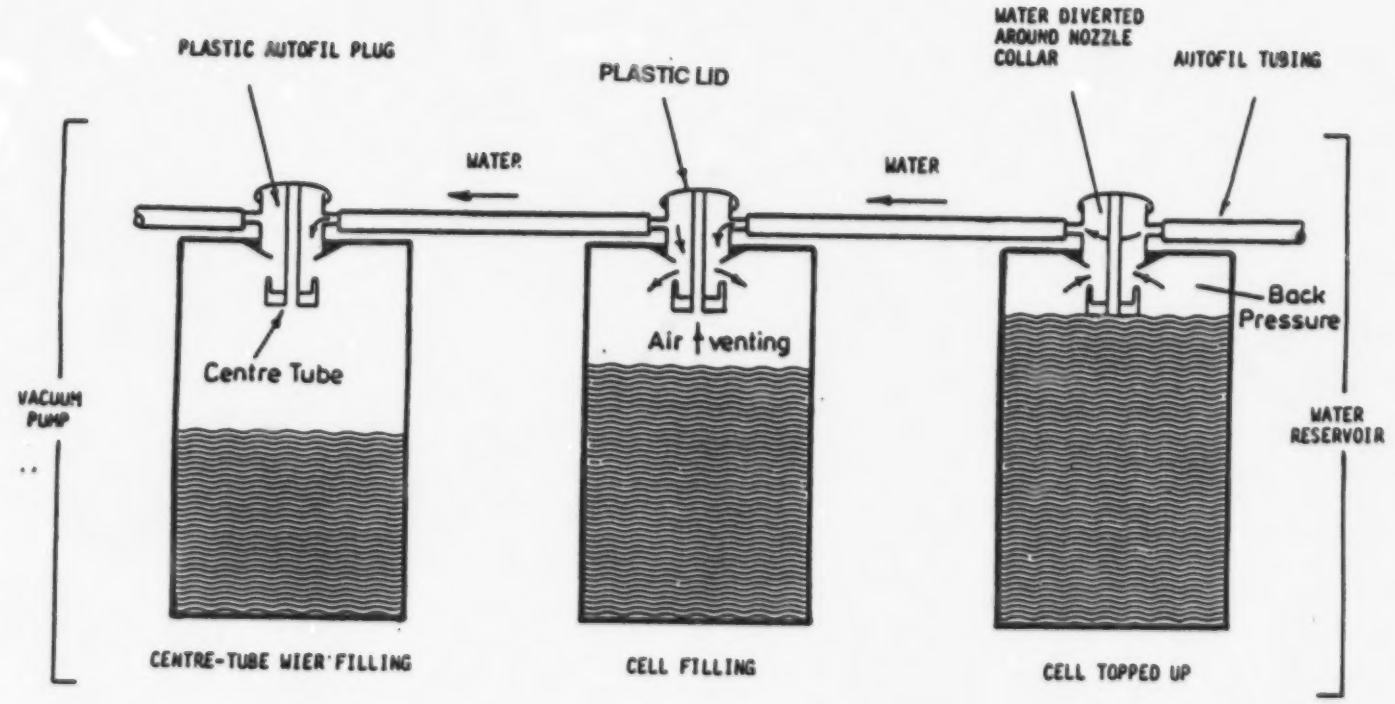


Figure 5/ Schematic Representation of Autofil in Operation

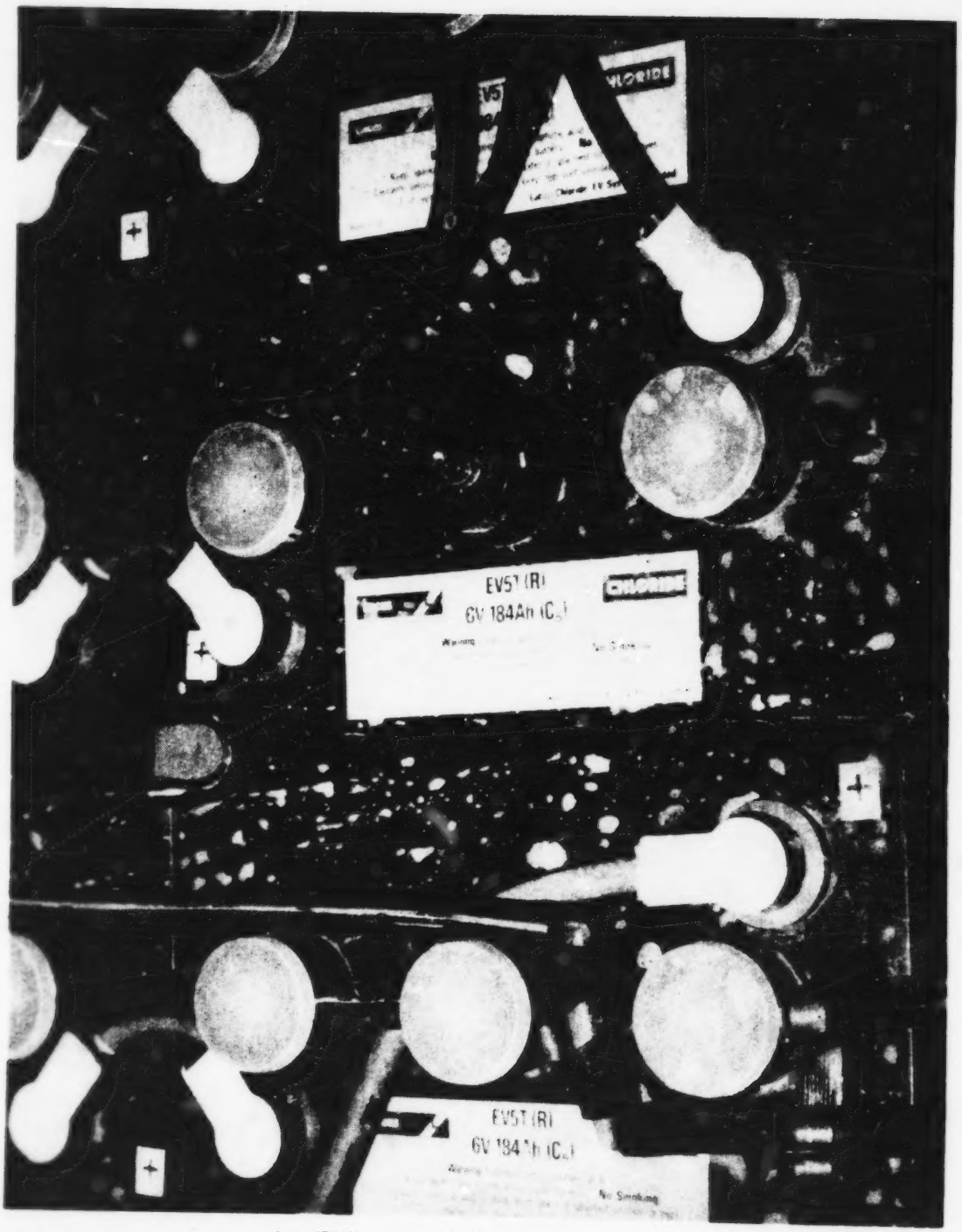


Figure 6/ Battery Cell with Plastic Lid Removed

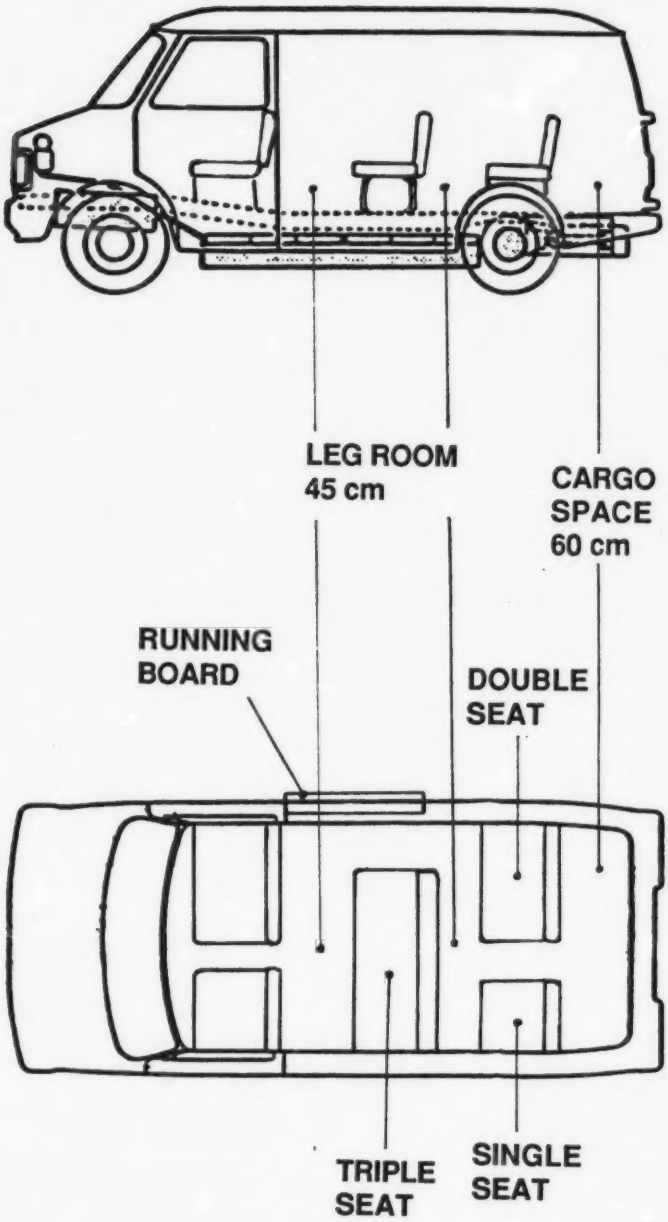


Figure 7/ Vehicle Interior Layout

Figure 8/ Running Board for Side Door Entrance

Figure 9/ Roof Vent

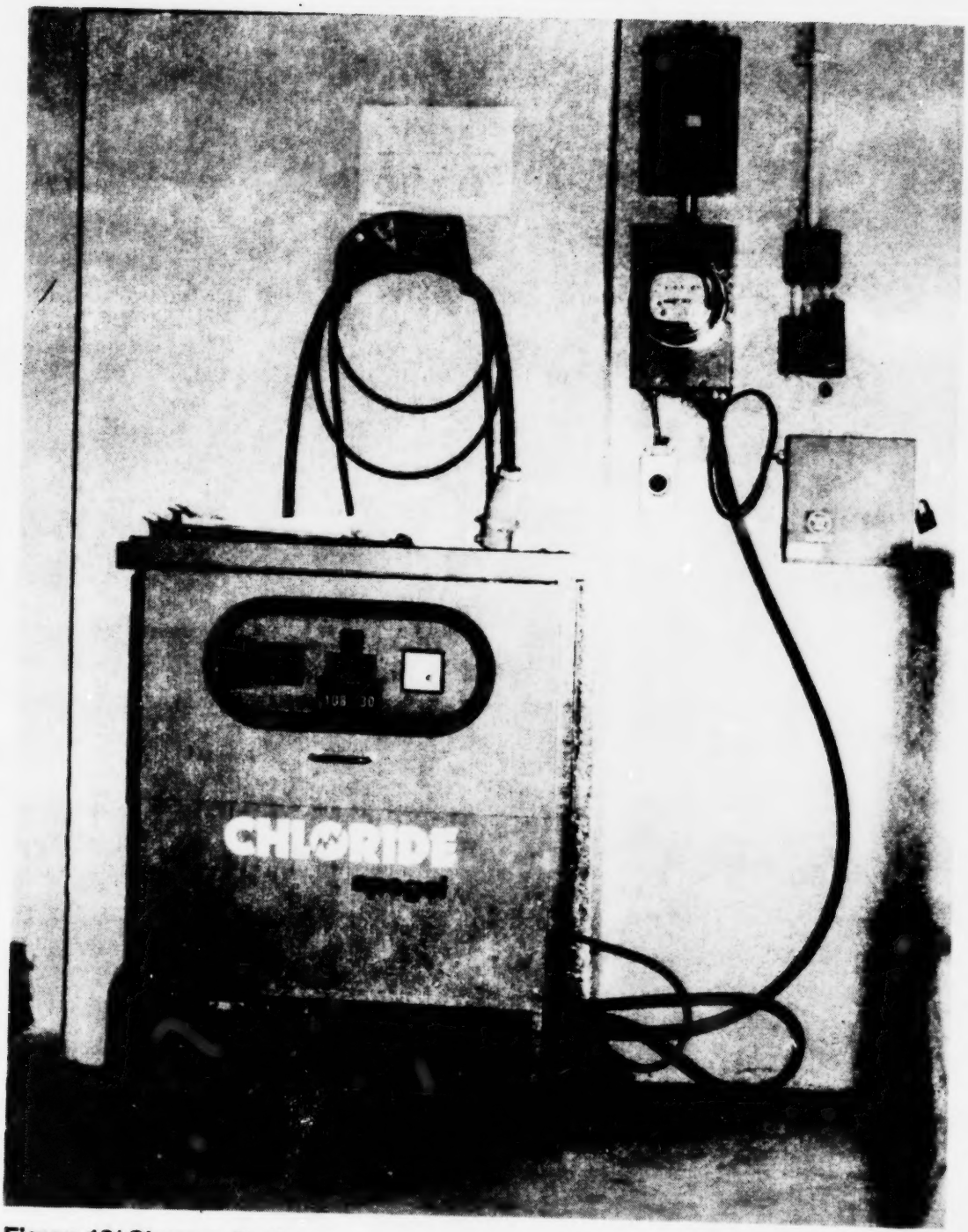


Figure 10/ Charger Station

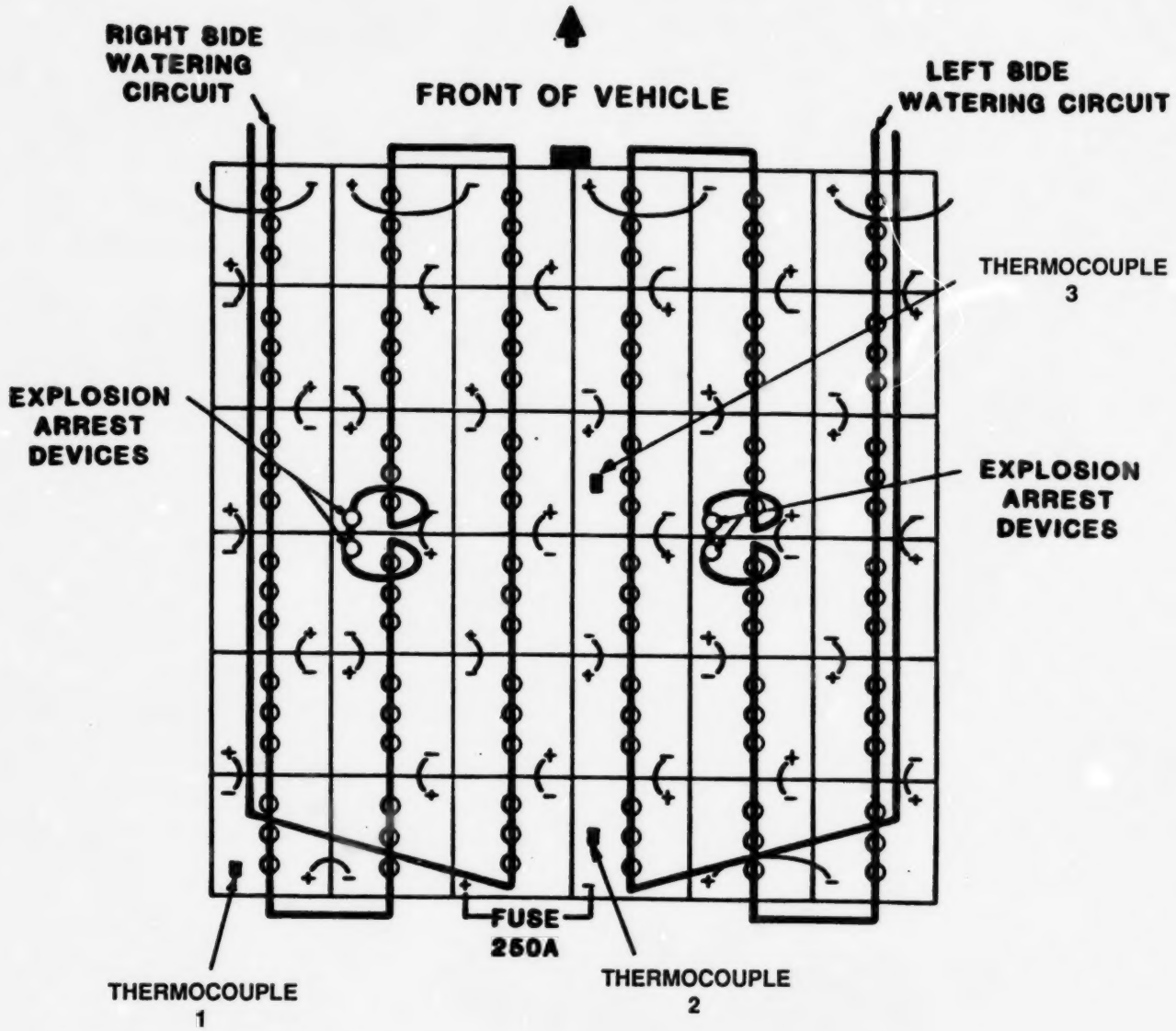
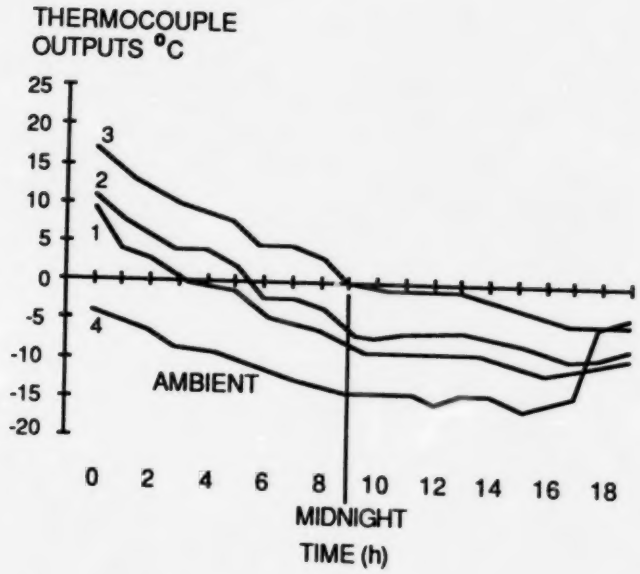


Figure 11/ Thermocouple Locations



t=0 3:00 P.M. Feb. 10,1985
t=19 10:00 A.M. Feb. 11, 1985

CONDITIONS: BATTERY PACK FULLY CHARGED
CHARGER OFF
HEATER OFF
VEHICLE AT OUTDOOR PARKING

AT t=-0.5, Vehicle was being moved out from indoor parking to outdoor parking

Figure 12/ Battery Pack Cooling

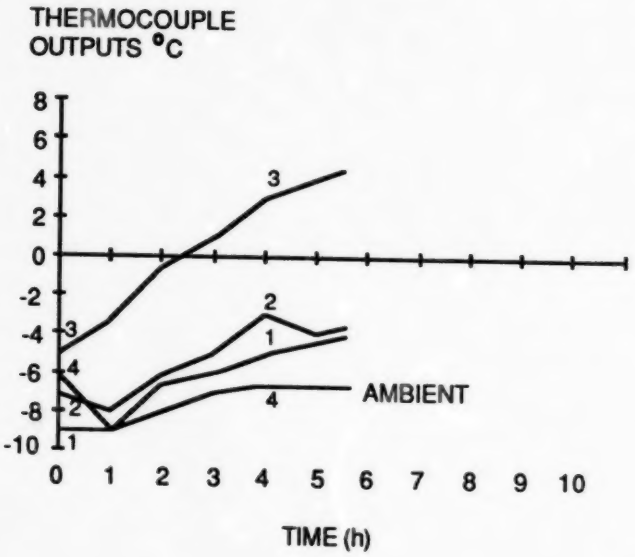


Figure 13/ Battery Pack Heating

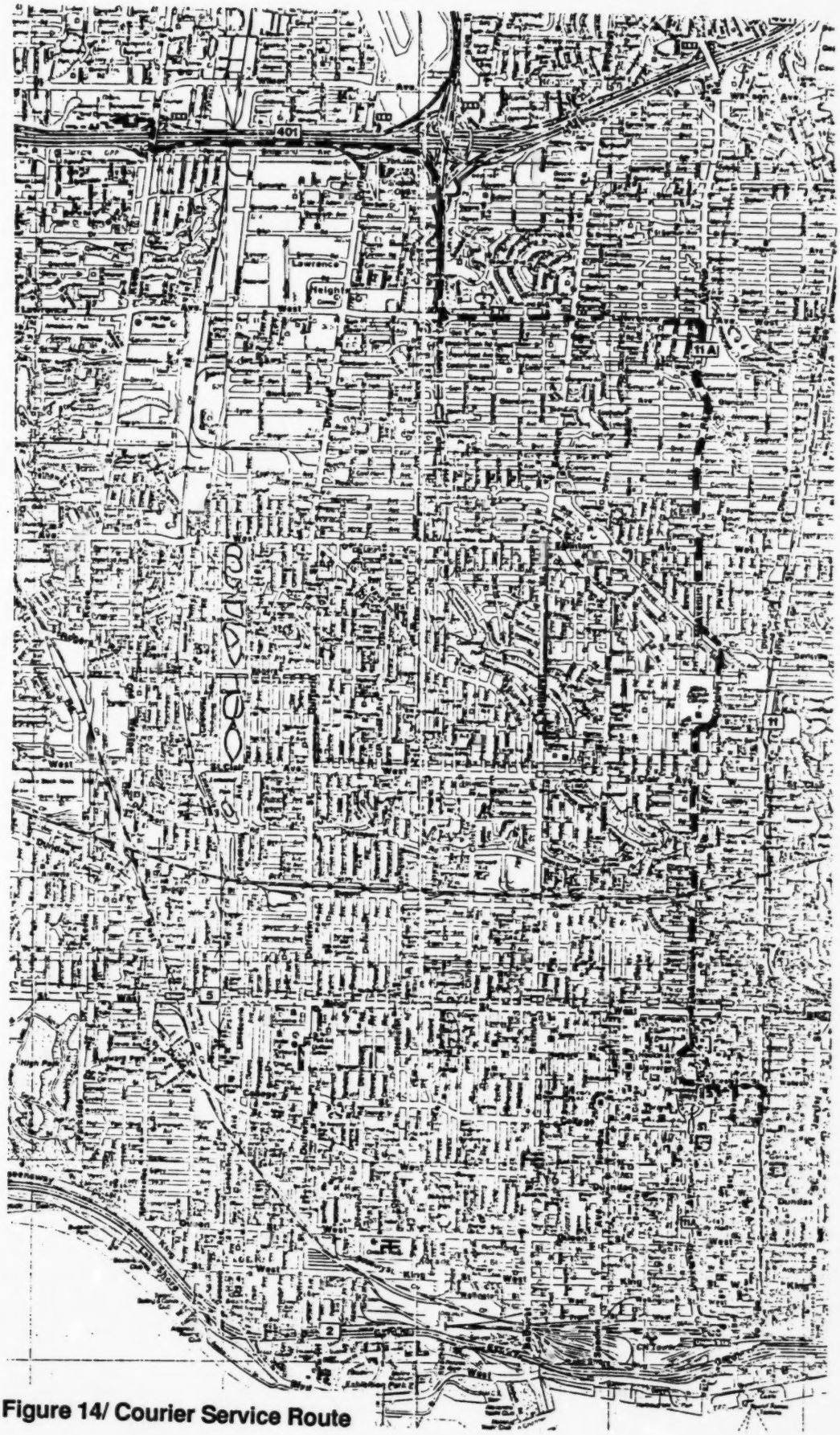


Figure 14/ Courier Service Route

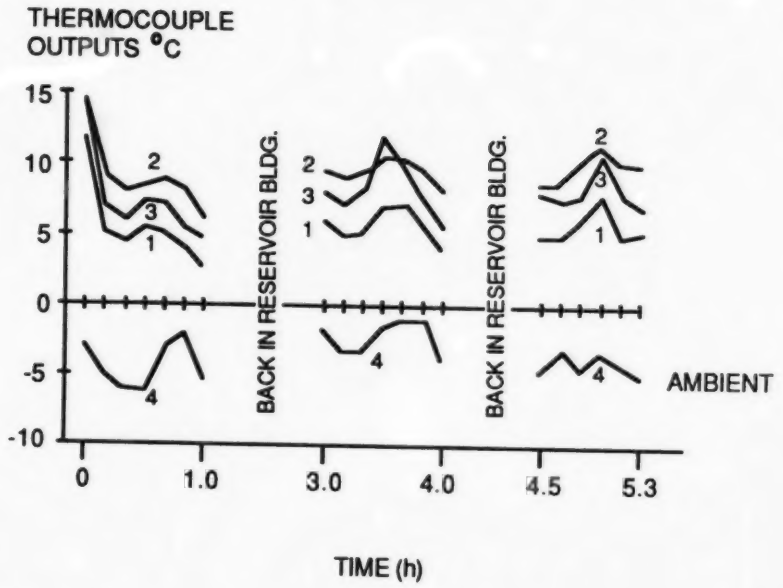


Figure 15/ Temperature Changes of Thermocouples During Simulated Courier Service Runs (t=0 corresponds to 10:00 A.M. Feb. 13,1986)

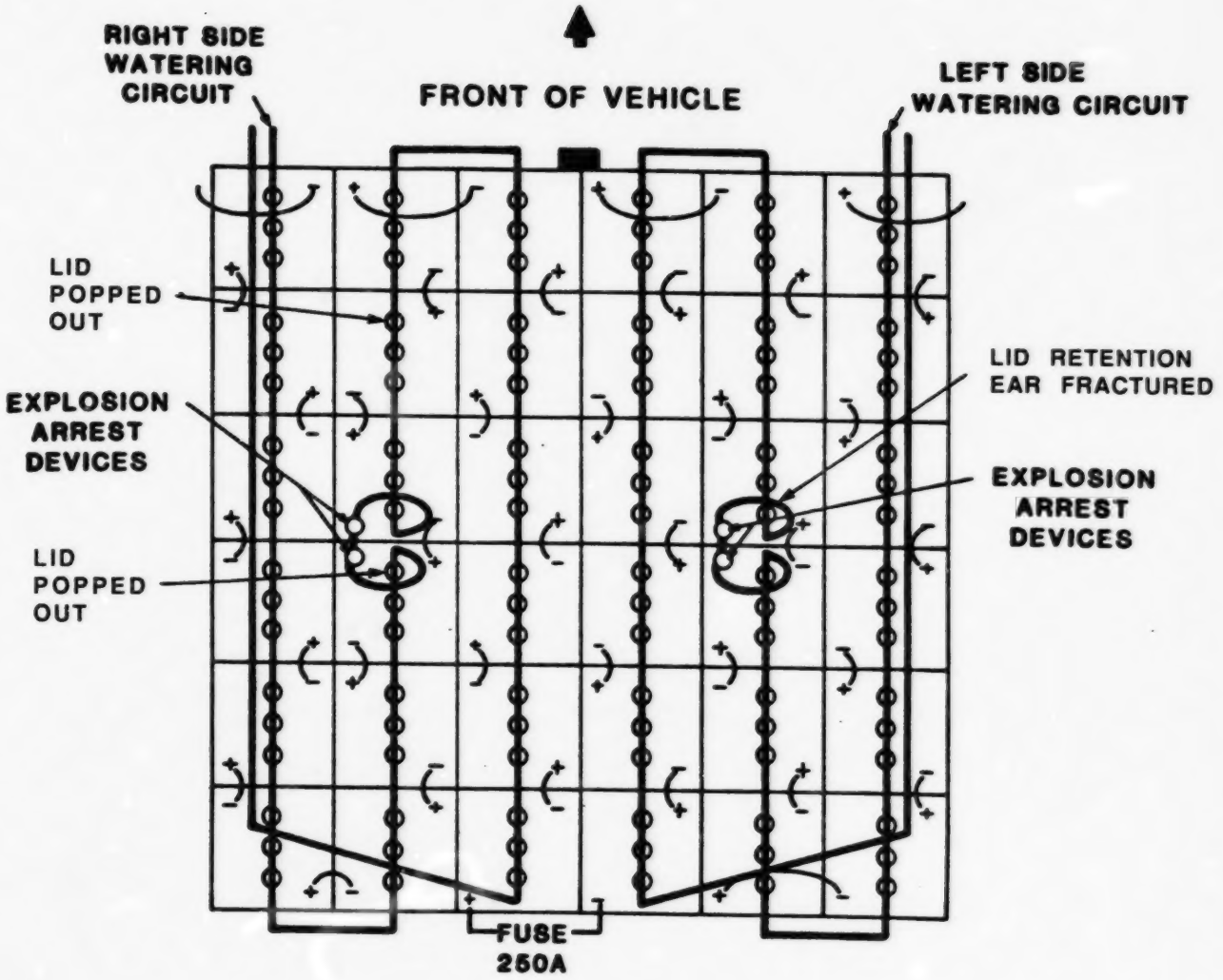


Figure 16/ EV11 – Vaqualok Lid Replacement Record

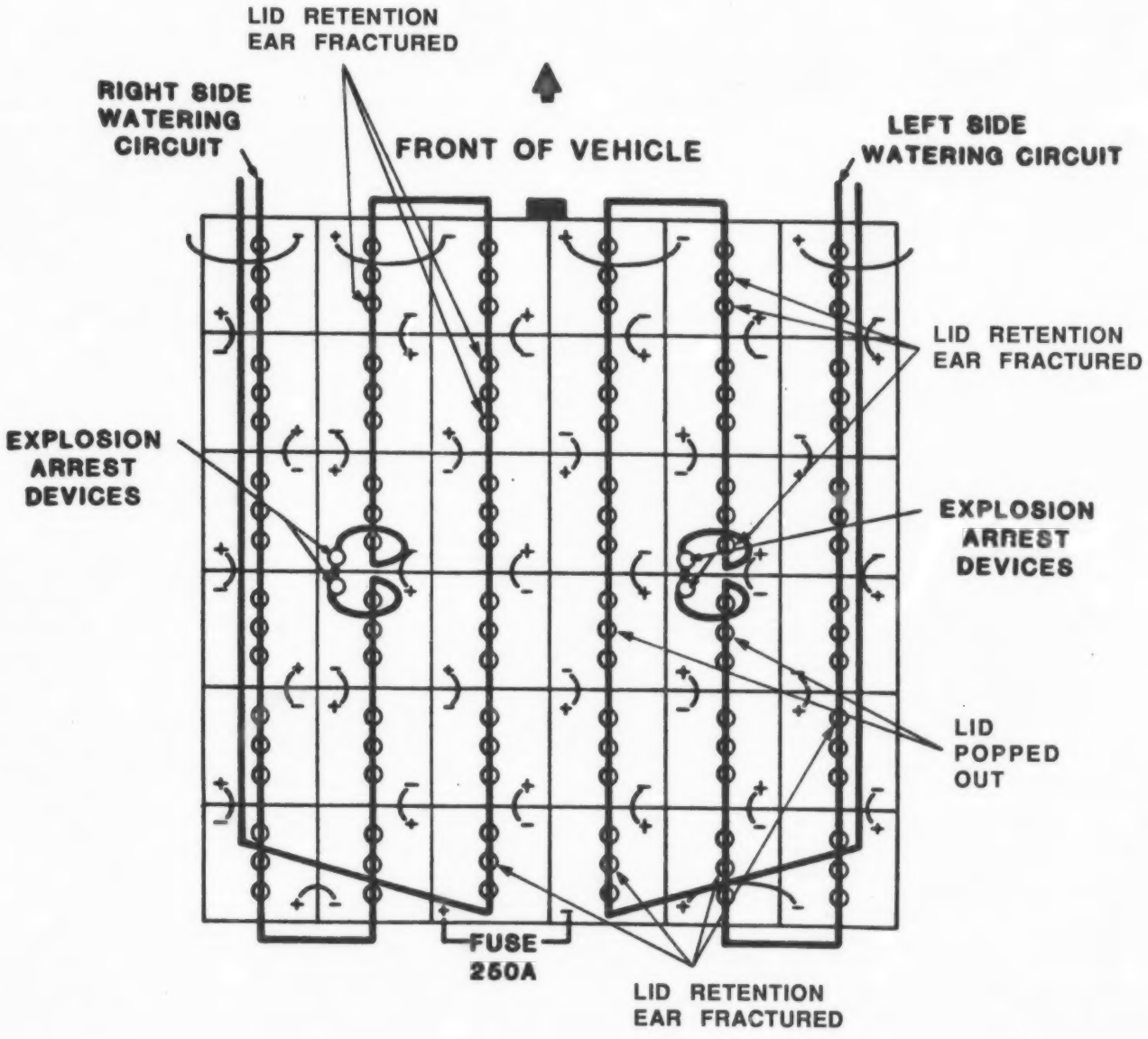


Figure 17/ EV12 – Vaqualok Lid Replacement Record

APPENDIX A/ VEHICLE DATA SUMMARY

1/ Manufacturer
Bedford Commercial Vehicles, Luton England
Division of General Motors Overseas Commercial
Vehicle Corporation

2/ Description
Name: Griffon (Bedford CF) Van
Model: Left-hand drive, right-hand side door
Drive: Rear-wheel
Interior: Nine-seat passenger van, locally converted

3/ Weight
Gross: 3 500 kg (7700 lb)
Curb: Front - 1290 kg (2845 lb)
Rear - 1565 kg (3450 lb)
Total - 2855 kg (6300 lb)
Max Payload: 645 kg (1420 lb)

4/ Dimension
Wheel base: 2.69 m (106 in)
Overall Length: 4.41 m (174 in)
Overall Height: 1.99 m (78 in)
Overall Width: 2.26 m (89 in)

5/ Heater
Fuel Tank: 13.6 L
Rating: 4300 W

6/ Propulsion Battery Pack
Manufacturer: Lucas Chloride EV Systems
Model Type: EV-5T lead acid, 6 V
Number of Modules: 36

Discharge Characteristics:
Average Discharge Voltage: 210 V
End of Discharge Voltage: 160 to 180 V
Current Under Peak Power
(40 kW) Conditions: 200 A

Battery Capacity
Discharged over 2 h: 165 Ah
Pack Weight: 1270 kg (2800 lb)
Central Point Watering: LCEVS Autofil
Connection between Modules: welded to terminals and encapsulated

7/ Ancillary Battery
Manufacturer: Lucas Chloride EV Systems
Type: Lead-acid
Voltage: 12 V nominal

8/ Controller
Manufacturer: Lucas Aerospace Ltd
Model: MK4
Battery Voltage: 150 - 250 V (216 V nominal)
Power Output: 40 kW (motor output)
Regenerative Braking: Down to zero speed

9/ DC-DC Convertor
Manufacturer: Lucas Micos Ltd
Model: PDA 1A/216
Input Voltage Range: 150-300 V (216 V nonminal)
Output Voltage: 14.3 V
Output Current: 25 A

10/ Propulsion Motor
Manufacturer: Lucas CAV Ltd
Model: MT 305/216 separately excited
Nominal Voltage: 216 V
Peak Power: 40 kW (30 min rating) at 3000 rpm
Maximum Torque: 250 Nm (5 min rating)
Maximum Speed: 6000 rpm

11/ Battery Charger
Manufacturer: Chloride Legg Ltd
Model: Spegel S1P 108/30
Input: 45 A, 200 - 250 V ac single phase, 60 hz
Output: 30 A
Maximum Output Power: 6.3 kW
Refreshing Charge: 10 min every 6 h
Termination of Charge: dv/dt plus adjustable up to 12 h timer

12/ Chassis/Body

Manufacturer:	Bedford Commercial Vehicles
Number of Doors:	5
Type of Doors:	2 front - side hinged 1 side sliding 2 rear - side hinged
Number of Windows:	2 roll-up; 2 sliding
Springs:	Front - helicoil coil Rear - single taper
Shocks:	Front and Rear - hydraulic
Front Axle:	Independent, upper and lower suspension arms
Rear Axle:	Salisbury 15 HA 4.89: 1 ratio, fully floating hubs
Transmission:	Single ratio chain-driven primary reduction unit integral with traction motor 1.92 : 1 short propshaft to rear axle
Steering:	Rack and pinion
Brakes:	Drum - Vacuum assisted
Tire size:	205 R 14C
Tire Pressure:	Front - 4.5 bar (65 psi) Rear - 5.1 bar (70 psi)

APPENDIX B/ PRELIMINARY VEHICLE CHECK FINDINGS

1/ For both vehicles

- The name plate Griffon is not available, the BEDFORD plate is used.
- The rubber band for motor air-inlet filters is cracked at the bend.
- The speedometer and odometer are marked in imperial system.

2/ Applies only to VIN No. FV 616917, licence plate No. EV 12

- The bolt holding the leaf-spring shackle was not tightened. It was fixed by MTC.
- The draining or hooking holes at the underside of the body frame were badly deformed.
- The underside of the battery pack was badly scratched and dented.

3/ Applies only to VIN No. FV 616930, licence plate No. EV 11

- The speedometer was not working, but was fixed by GMC Truck Centre, Toronto.
- The rubber cover for the speed transducer was split open.
- The inside door handle for the side door was damaged.
- The groove for the side door roller is covered with grease. It has no mechanism to prevent passengers touching the grease.
- The interior panel, between the side door and the front passenger seat was not done.
- The underside of the battery pack tray was badly scratched and dented.
- The draining or hooking holes at the underside of the vehicle body frame were badly deformed.
- The door handle for the rear door was broken when it was being used the second time. MTC replaced the centre piece of the handle which fixed the problem.
- The linkage for the rear door lock mechanism vibrates.
- The seat mountings that hold the seats to the floor were not strong enough.
- The watering block cover locking mechanism was broken.
- One of the battery cell plastic cover latches was broken.

APPENDIX C/ MECHANICAL CHECK LIST

9/10/85

BEDFORD CF ELECTRIC VAN
VEHICLE INITIAL INSPECTION

VIN: FV616930 : PASSENGER VAN (P.E)

Odometer: 111 :

Date Received: 17-9-85

MECHANICAL CHECKLIST

See attached photographs

		Tick Box		
		OK	Attn Req'd	Fixed
1.	**Visual Inspection**			
1.1	Inspect vehicle for damage during shipping			
1.2	Does vehicle conform to ordering specification	✓		
1.3	Is literature supplied as follows:			
	a. Bedford CF Owner's Manual and Electric Van Supplement	✓		
	b. Eberspacher (ESPAR) heater manual		✓	
	c. Chloride Spegal charger installation and operating instructions	✓		
	d. Service Information package	✓		
1.4	Inspect watering trolley and charger for signs of transit damage	✓		
1.5	Check fluid levels on following:			
	a. Brake fluid	✓		
	b. Rear axle	✓		
	c. Primary chain drive	✓		
	d. Windshield washer	✓		
	e. Heater fuel	✓		
1.6	Inspect front and rear suspension for signs of component wear or failure	✓		
1.7	Examine door and hood safety latches for proper engagement	✓	.	

MECHANICAL CHECKLIST (continued)

		Tick Box		
		OK	Attn Req'd	Fixed
2.	**Battery Watering System**			
2.1	Check vacuum integrity of battery watering circuit	✓		
2.2	Check operation of watering trolley	✓		
3.	**Tires**			
3.1	Check tire pressures			
	a. Front -- 65 psi	✓		
	b. Back -- 70 psi	✓		
3.2	Check front wheels for proper alignment	✓		
4.	**Test Drive**			
4.1	Van stops from 20 mph within 30 feet and does not pull to either side			
4.2	Parking brake operates and prevents van from rolling on a 15% incline			
4.3	Heater and defroster operate properly	✓		
4.4	Windshield wipers and washer operate properly	✓		
4.5	The following control devices operate properly:			
	a. Direction selector switch	✓		
	b. Regen braking override switch	✓		
	c. Battery state of charge gauge	✓		
	d. Heater fuel gauge	✓		
4.6	The following lights operate properly:			
	a. Headlight low beams	✓		
	b. Headlight high beams		✓	✓
	c. Parking lights	✓		
	d. Tail lights	✓		

MECHANICAL CHECKLIST (continued)

	Tick Box		
	OK	Attn Req'd	Fixed
e. Stop lights	✓		
f. Directional lights (front and rear)	✓		
g. Back-up lights	✓		
h. License plate lights	✓		
i. Side lights	✓		
j. Interior lights	✓		
k. Dashboard lights	✓		

ELECTRICAL CHECKLIST

	Tick Box		
	OK	Attn Req'd	Fixed
1. 12 V Battery Connections			
1.1 Cleanliness of battery terminal parts and connectors.	✓		
1.2 Tightness of bolted terminals.	✓		
1.3 Terminals to be greased (with petroleum jelly) after tightening. Also grease negative connection to chassis.	✓		
1.4 Damage to wires and cables.	✓		
1.5 Visual inspection of battery.	✓		
2. Vehicle Insulation Test			
Traction motor insulation is to be checked separately from all other equipment.			
Procedure as follows:			
2.1 Unplug both 216 V battery connectors and disconnect both motor armature ERMA connectors and field connector.	✓		

ELECTRICAL CHECKLIST (continued)

	Tick Box		
	OK	Attn Req'd	Fixed
2.2 Short +ve and -ve 216 V battery cables inside the SIM box (eg using wire with alligator clips across contactor terminals). CAUTION: Be certain battery has been disconnected before performing this step.	✓		
2.3 Switch on vehicle IGN. and select direction to close isolation contactors.	✓		
2.4 Megger test at 500 V, between shorted 216 V battery cables and vehicle chassis. (Carry out 2 separate megger tests, reversing megger polarity on the second test). Insulation should be greater than 40 megohms. If not, investigate cause and record findings.	✓		
Minimum resistance ∞ MΩ Ohms			
2.5 Check motor armature and field insulation separately to vehicle chassis with megger set to 500 V, reversing polarity as in 2d above. Record lowest reading for field and armature separately.	✓		
Minimum armature resistance ∞ MΩ Ohms			
Minimum field resistance ∞ MΩ Ohms			

3. Inspection Inside SIM Box

Check the following:

3.1 Condition of 35 mm cable lug terminations/crimps by pulling the cables and looking for signs of overheating. Remove any signs of oxidation.	✓		
3.2 Tightness of bottom nut securing contactor terminal to moulding. (Check torque - 12 Nm).	✓		
3.3 Tightness of cable lug connections to contactor terminals. (Check torque - 12 Nm).	✓		
3.4 Condition of charge wiring ring terminals/crimps as in 3.b above.	✓		
3.5 Condition of all fuses and fuse holders on SIM pcb ie, 2 x 35 amp, 2 x 10 amp and 2 x 1 amp (35 amp fuses 4 bolts torque 3.4 Nm).	✓		

ELECTRICAL CHECKLIST (continued)

		Tick Box		
		OK	Attn Req'd	Fixed
3.6	BICC VERO connectors to SIM pcb, (ie. 1 off x 12 way, 1 off x 6 way to 1 off x 3 way) check for correct mating, contacts pushed back, damaged connector mouldings and damaged wires.	✓		
3.7	Check connections to both contactor coils.	✓		
3.8	Inspect the surface condition of the iso contactor contacts for signs of overheating and pitting and report any found.	✓		
3.9	Check tightness of ground connection to box and lid and apply rust inhibitor type LPS3 or petroleum jelly, sparingly if needed.	✓		
4.	Inspection Outside SIM Box			
4.1	Check charge socket for signs of overheating and general mechanical condition.	✓		
4.2	Lubricate charge socket contacts with RS Contact Lubricant 5S4-175 or Contact Treatment Oil - 2 Ax (Farnell - SOB 170).	✓		
5.	Inspection of Small Signal Connectors and Wiring			
5.1	Check the following items for: Correct mating of connectors Contacts pushed back Damaged connector mouldings Damaged wires			
5.1.1	35 way BICC VERO controller plug and SIM box socket	✓		
5.1.2	12 way BICC VERO dash/bulkhead connector	✓		
5.1.3	Foot pedal pot. connectors (Packard)	✓		
5.2	Check that no wiring is under tension, chafing on bodywork/subframe, etc.	✓		
6.	Motor and Choke Connectors			
6.1	Check that the 3 ERMA connectors are correctly mated. Check that contacts are in correct position and are not loose in rubber sleeve (i.e. rubber sleeve faulty).	✓		

ELECTRICAL CHECKLIST (continued)

	Tick Box		
	OK	Attn Req'd	Fixed
6.2 Lightly grease rubber sleeves with silicone grease or petroleum jelly and re-mate connectors. CAUTION: Keep grease away from contacts.	✓		
6.3 Check field connector (2 pin Packard) and integrity of the sleeve. Also check moulding for damage.	✓		
7. Battery Connectors			
SAFETY NOTE: Adopt sensible precautions when working on live battery packs.			
7.1 Check that the ERMA connectors are correctly mated. Check that contacts are not loose in the rubber sleeves and are correctly located.	✓		
7.2 Check that plastic 'finger-proof' shrouds are fitted to socket contacts.	✓		
7.3 Check condition of contacts and wash out any grease with contact cleaner.	✓		
7.4 Lightly grease rubber sleeves with silicone grease or petroleum jelly. CAUTION: Keep grease away from contacts.	✓		
8. Ground Contacts			
Check integrity of the following ground contacts:			
Motor	✓		
Controller	✓		
Subframe	✓		
12 V battery	✓		
NOTE: Grease all chassis bonding points with petroleum jelly or waterproof grease (ex. Keenol).			
9. Pedal Pot. Assemblies			
Check the following:			
9.1 Zero and full travel is obtainable on both potentiometers.	✓		

ELECTRICAL CHECKLIST (continued)

		Tick Box		
		OK	Attn Req'd	Fixed
9.2	Condition of potentiometers and wiring.	✓		
9.3	Condition of mechanical assembly for free operation. Lubricate if necessary.	✓		
10.	Direction Switches			
	Check operation of Fwd/Rev and Regen O/ride switches. Lubricate if required. See service bulletin No. 29.	✓		
11.	Motor			
11.1	Condition of banding/winding at drive end for fraying/movement of windings and burning of fan blades.	✓		
11.2	Condition of brushgear and commutator, i.e. freedom of brushes in boxes, burning of comm. bars, etc.	✓		
11.3	Condition of cables for chafing at exit from glands and elsewhere.	✓		
11.4	Motor air filter mesh not pushed into motor.	✓		
11.5	Single core field wires inside motor are well clear of the armature (commutator end).	✓		
12.	Converter and Wiring			
12.1	Check condition of converter flying leads.	✓		
12.2	Check condition of 12 V output connector.	✓		
12.3	Check security of converter to subframe.	✓		
13.	Cable Routing			
13.1	Check positioning of battery B+, B- cables clear of 35 way umbilical cable. Distance of separation to be at least 25 mm.	✓		
14.	Standard Vehicle Wiring			
14.1	Check that rear light wiring harness is not trapped between the spring hangers and rear valence and is not pulled tight against the edge of holes through the chassis bodywork.	✓		

ELECTRICAL CHECKLIST (continued)

	Tick Box		
	OK	Attn Req'd	Fixed
15. Accessories			
Radios			
15.1 Where a radio or radio telephone is fitted, check that cables are not trapped under the engine cover, that no cables are chafed and the antenna braid is correctly terminated at the antenna.	N/A		
15.2 Where applicable - check the operation of the vehicle when using the transmitter of a radio telephone. Check particularly for faulty motor speed or operation when the transmitter is operated.	N/A		

8/10/85

BEDFORD CF ELECTRIC VAN
VEHICLE INITIAL INSPECTION

VIN: FV616917 : CARGO VAN (CF)

Odometer: 76 :

Date Received: 18/9/85

MECHANICAL CHECKLIST

		Tick Box		
		OK	Attn Req'd	Fixed
1.	**Visual Inspection** (SEE ATTACHED PHOTOGRAPHS)			
1.1	Inspect vehicle for damage during shipping		✓		*
1.2	Does vehicle conform to ordering specification	✓		
1.3	Is literature supplied as follows:			
	a. Bedford CF Owner's Manual and Electric Van Supplement	✓		
	b. Eberspacher (ESPAR) heater manual		✓	
	c. Chloride Spegal charger installation and operating instructions	✓		
	d. Service Information package	✓		
1.4	Inspect watering trolley and charger for signs of transit damage	✓		
1.5	Check fluid levels on following:			
	a. Brake fluid		✓	✓
	b. Rear axle		✓	✓
	c. Primary chain drive	✓		
	d. Windshield washer	✓		
	e. Heater fuel	✓		
1.6	Inspect front and rear suspension for signs of component wear or failure	✓		
1.7	Examine door and hood safety latches for proper engagement	✓		

MECHANICAL CHECKLIST (continued)

		Tick Box		
		OK	Attn Req'd	Fixed
2.	**Battery Watering System**			
2.1	Check vacuum integrity of battery watering circuit	✓		
2.2	Check operation of watering trolley	✓		
3.	**Tires**			
3.1	Check tire pressures			
	a. Front -- 65 psi	✓		
	b. Back -- 70 psi	✓		
3.2	Check front wheels for proper alignment	✓		
4.	**Test Drive**			
4.1	Van stops from 20 mph within 30 feet and does not pull to either side	✓		
4.2	Parking brake operates and prevents van from rolling on a 15% incline	✓		
4.3	Heater and defroster operate properly	✓		
4.4	Windshield wipers and washer operate properly	✓		
4.5	The following control devices operate properly:			
	a. Direction selector switch	✓		
	b. Regen braking override switch	✓		
	c. Battery state of charge gauge	✓		
	d. Heater fuel gauge	✓		
4.6	The following lights operate properly:			
	a. Headlight low beams	✓		
	b. Headlight high beams	✓		
	c. Parking lights	✓		
	d. Tail lights	✓		

MECHANICAL CHECKLIST (continued)

	Tick Box		
	OK	Attn Req'd	Fixed
e. Stop lights	✓		
f. Directional lights (front and rear)	✓		
g. Back-up lights	✓		
h. License plate lights	✓		
i. Side lights	✓		
j. Interior lights	✓		
k. Dashboard lights	✓		

ELECTRICAL CHECKLIST

	Tick Box		
	OK	Attn Req'd	Fixed
1. 12 V Battery Connections			
1.1 Cleanliness of battery terminal parts and connectors.	✓		
1.2 Tightness of bolted terminals.	✓		
1.3 Terminals to be greased (with petroleum jelly) after tightening. Also grease negative connection to chassis.	✓		
1.4 Damage to wires and cables.	✓		
1.5 Visual inspection of battery.	✓		
2. Vehicle Insulation Test			

Traction motor insulation is to be checked separately from all other equipment.

Procedure as follows:

2.1 Unplug both 216 V battery connectors and disconnect both motor armature ERMA connectors and field connector.	✓		

ELECTRICAL CHECKLIST (continued)

	Tick Box		
	OK	Attn Req'd	Fixed
2.2 Short +ve and -ve 216 V battery cables inside the SIM box (eg using wire with alligator clips across contactor terminals). CAUTION: Be certain battery has been disconnected before performing this step.	✓		
2.3 Switch on vehicle IGN. and select direction to close isolation contactors.	✓		
2.4 Megger test at 500 V, between shorted 216 V battery cables and vehicle chassis. (Carry out 2 separate megger tests, reversing megger polarity on the second test). Insulation should be greater than 40 megohms. If not, investigate cause and record findings.	✓		
Minimum resistance ∞ Ohms			
2.5 Check motor armature and field insulation separately to vehicle chassis with megger set to 500 V, reversing polarity as in 2d above. Record lowest reading for field and armature separately.	✓		
Minimum armature resistance ∞ Ohms			
Minimum field resistance ∞ Ohms			

3. Inspection Inside SIM Box

Check the following:

3.1 Condition of 35 mm cable lug terminations/crimps by pulling the cables and looking for signs of overheating. Remove any signs of oxidation.	✓		
3.2 Tightness of bottom nut securing contactor terminal to moulding. (Check torque - 12 Nm).	✓		
3.3 Tightness of cable lug connections to contactor terminals. (Check torque - 12 Nm).	✓		
3.4 Condition of charge wiring ring terminals/crimps as in 3.b above.	✓		
3.5 Condition of all fuses and fuse holders on SIM pcb ie, 2 x 35 amp, 2 x 10 amp and 2 x 1 amp (35 amp fuses 4 bolts torque 3.4 Nm).	✓		

ELECTRICAL CHECKLIST (continued)

		Tick Box		
		OK	Attn Req'd	Fixed
3.6	BICC VERO connectors to SIM pcb, (ie. 1 off x 12 way, 1 off x 6 way to 1 off x 3 way) check for correct mating, contacts pushed back, damaged connector mouldings and damaged wires.	✓		
3.7	Check connections to both contactor coils.	✓		
3.8	Inspect the surface condition of the iso contactor contacts for signs of overheating and pitting and report any found.	✓		
3.9	Check tightness of ground connection to box and lid and apply rust inhibitor type LPS3 or petroleum jelly, sparingly if needed.	✓		
4.	Inspection Outside SIM Box			
4.1	Check charge socket for signs of overheating and general mechanical condition.	✓		
4.2	Lubricate charge socket contacts with RS Contact Lubricant 5S4-175 or Contact Treatment Oil - 2 Ax (Farnell - SOB 170).	✓		
5.	Inspection of Small Signal Connectors and Wiring			
5.1	Check the following items for: Correct mating of connectors Contacts pushed back Damaged connector mouldings Damaged wires			
5.1.1	35 way BICC VERO controller plug and SIM box socket	✓		
5.1.2	12 way BICC VERO dash/bulkhead connector	✓		
5.1.3	Foot pedal pot. connectors (Packard)	✓		
5.2	Check that no wiring is under tension, chafing on bodywork/subframe, etc.	✓		
6.	Motor and Choke Connectors			
6.1	Check that the 3 ERMA connectors are correctly mated. Check that contacts are in correct position and are not loose in rubber sleeve (i.e. rubber sleeve faulty).	✓		

ELECTRICAL CHECKLIST (continued)

		Tick Box		
		OK	Attn Req'd	Fixed
6.2	Lightly grease rubber sleeves with silicone grease or petroleum jelly and re-mate connectors. CAUTION: Keep grease away from contacts.	✓		
6.3	Check field connector (2 pin Packard) and integrity of the sleeve. Also check moulding for damage.	✓		
7.	**Battery Connectors**			
	SAFETY NOTE: Adopt sensible precautions when working on live battery packs.			
7.1	Check that the ERMA connectors are correctly mated. Check that contacts are not loose in the rubber sleeves and are correctly located.	✓		
7.2	Check that plastic 'finger-proof' shrouds are fitted to socket contacts.	✓		
7.3	Check condition of contacts and wash out any grease with contact cleaner.	✓		
7.4	Lightly grease rubber sleeves with silicone grease or petroleum jelly. CAUTION: Keep grease away from contacts.	✓		
8.	**Ground Contacts**			
	Check integrity of the following ground contacts:			
	Motor	✓		
	Controller	✓		
	Subframe	✓		
	12 V battery	✓		
	NOTE: Grease all chassis bonding points with petroleum jelly or waterproof grease (ex. Keenol).			
9.	**Pedal Pot. Assemblies**			
	Check the following:			
9.1	Zero and full travel is obtainable on both potentiometers.	✓		

ELECTRICAL CHECKLIST (continued)

		Tick Box		
		OK	Attn Req'd	Fixed
9.2	Condition of potentiometers and wiring.	✓		
9.3	Condition of mechanical assembly for free operation. Lubricate if necessary.	✓		
10.	Direction Switches			
	Check operation of Fwd/Rev and Regen O/ride switches. Lubricate if required. See service bulletin No. 29.	✓		
11.	Motor			
11.1	Condition of banding/winding at drive end for fraying/movement of windings and burning of fan blades.	✓		
11.2	Condition of brushgear and commutator, i.e. freedom of brushes in boxes, burning of comm. bars, etc.	✓		
11.3	Condition of cables for chafing at exit from glands and elsewhere.	✓		
11.4	Motor air filter mesh not pushed into motor.	✓		
11.5	Single core field wires inside motor are well clear of the armature (commutator end).	✓		
12.	Converter and Wiring			
12.1	Check condition of converter flying leads.	✓		
12.2	Check condition of 12 V output connector.	✓		
12.3	Check security of converter to subframe.	✓		
13.	Cable Routing			
13.1	Check positioning of battery B+, B- cables clear of 35 way umbilical cable. Distance of separation to be at least 25 mm.	✓		
14.	Standard Vehicle Wiring			
14.1	Check that rear light wiring harness is not trapped between the spring hangers and rear valence and is not pulled tight against the edge of holes through the chassis bodywork.	✓		

ELECTRICAL CHECKLIST (continued)

	Tick Box	
OK	Attn Req'd	Fixed

15. Accessories

Radios

15.1 Where a radio or radio telephone is fitted, check that cables are not trapped under the engine cover, that no cables are chafed and the antenna braid is correctly terminated at the antenna.

N/A

15.2 Where applicable - check the operation of the vehicle when using the transmitter of a radio telephone. Check particularly for faulty motor speed or operation when the transmitter is operated.

N/A

APPENDIX D/ DC ENERGY AND POWER CONSUMPTION AT CONSTANT SPEED

Test performed by: Tennessee Valley Authority
Test conducted at: Electric Vehicle Test Facility, Chattanooga, Tennessee
Test Vehicle Weight: 3070 kg (6770 lbs)

Speed km/h	Speed mph	Power kW	Energy Consumption Wh/km	Energy Consumption Wh/mi
16	10	2.7	161	260
24	15	3.8	157	253
32	20	5.3	162	262
40	25	6.9	169	273
48	30	8.8	182	293
56	35	11.5	204	330
64	40	14.5	223	360
72	45	18.2	253	408
80	50	26.2	306	494

Extracted from: Test and Evaluation Report for the Beford Van, EPRI Research Project 1136-17 April 1985.